

In re Patent Application of:
DOUGHERTY ET AL
Serial No. 10/629,143
Filed: JULY 29, 2003

IN THE SPECIFICATION:

Please replace the identified paragraphs with the following amended paragraphs:

[1] This invention relates to an optical waveguide tap, which has is comprised of a waveguide coupler, followed by a waveguide bend that subjects tapped light passing therethrough from the waveguide coupler to polarization dependent loss, that is effectively complementary to and thereby compensates for polarization dependent loss introduced into the tapped light by the waveguide coupler, so that the result of combining the waveguide coupler with the waveguide bend is to produce substantially no resultant or net polarization dependent loss from an input end to an output tap end of the optical waveguide tap.

[12] It is an object of this invention to provide a relatively inexpensive, controlled process and optical circuit substantially having no PDL in a combination of waveguide coupler and bend components that make up an optical tap, between an input and output ports, and said bend component being operative to substantially compensate for polarization dependent loss that the tap would otherwise have suffered from significant PDL between its input and output ports, absent the bend component.

[13] In accordance with an aspect of this invention, a planar optical waveguide tap substantially absent of, in which polarization dependent loss is substantially compensated from an input end to an output end, comprises: is provided, comprising:

[15] a second optical waveguide having at least a coupling portion adjacent and proximate to the first optical waveguide for receiving a portion of light launched into the first optical waveguide into the second optical waveguide, said coupling portion [.] inherently coupling light in a substantially polarization dependent manner, such that a first polarization mode couples significantly more strongly than a second polarization mode into the second optical waveguide from the first optical waveguide, so that light of the second polarization received into the second optical waveguide from the first optical

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waveguide experiences higher optical loss through said coupling portion than light of said first polarization; and

[16] a bend portion of the second optical waveguide distinct from the coupling portion and being positioned between the coupling portion and the output end, and having at least one predetermined bend therein for transmitting light therethrough in a substantially polarization dependent manner, so that which allows light of the first polarization mode to radiate radiates out of the bend portion of the waveguide into a cladding about the bend portion with greater efficiency, and thereby experiences higher optical loss in the bend, than light of the second polarization mode, so as to substantially compensate for thereby effectively nulling a polarization dependent loss dependence that occurs from the coupling portion, for light which remains with the second optical waveguide after passing through the bend portion exiting the output end.

[18] a portion of the second optical waveguide having at least one bend therein, a respective bend thereby causing light in the first polarization mode[,] to radiate out a core of said respective bend portion with greater efficiency, and thereby experience higher optical loss in the respective bend, than light in the second polarization mode, so as to substantially null compensate for the insertion loss difference I_A for light coupled from the first optical waveguide to the second optical waveguide after passing through the respective bend thereof.

[19] In accordance with the invention there is further provided a polarization compensated planar waveguide compensated-branch comprising:

[20] a planar optical trunk waveguide for transporting a linearly un-polarized an optical signal having TE and TM modes;

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[21] a planar optical branch waveguide, capable of supporting TE and TM modes optically coupled to the trunk waveguide such that at least a portion of the optical signal propagating within the trunk waveguide will couple into the branch waveguide having an with a coupling imbalance between the TE and TM modes, with causing stronger TM mode coupling than TE mode coupling, and thereby higher optical loss for the TE mode than for the TM mode, for the at least a portion of the optical signal which couples into the branch waveguide from the trunk waveguide; wherein a portion of said branch waveguide, or a waveguide portion optically downstream from a region where coupling takes place between the trunk and branch waveguides, or a waveguide portion optically coupled thereto, for and receiving the at least a portion of the optical signal, has at least a predetermined bend with a predetermined radius for transmitting light therethrough in a substantially polarization dependent manner, so as to cause higher optical loss in the predetermined bend for the TM mode than for the TE mode, thereby compensating for an the coupling imbalance between[in] the TM and TE modes mode caused by light optically coupling into the branch from the trunk waveguide.

[22] In accordance with a further feature of the invention, there is provided a chip for transporting a plurality of optical signals having a plurality of separate trunk waveguides within [a]the same or common substrate, each having a branch waveguide optically coupled thereto by separate coupling regions, each optical coupling at each coupling region inducing exhibiting an imbalance in TE and TM mode coupling, thereby inducing polarization dependent loss for light coupled coupling from each trunk to a respective branch waveguide. [the] The chip has the following improvement comprising:

[23] each branch waveguide having includes a waveguide region that is downstream from said coupling region, the waveguide region having at least a predetermined bend therein, for transmitting light therethrough in a substantially polarization dependent manner, and offsetting and compensating for said imbalance to effectively null said imbalance in TE and TM mode coupling, to realize light transmission from the trunk waveguide to the

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branch waveguide passing through the bend with a substantially reduced resultant or net polarization dependent loss modes.

[28] Figure 2 is a diagram of a prior-art polarization independent tap, having two directional couplers with distinct coupling ratios such that the polarization dependence of the first coupler is compensated by the opposite polarization dependence of cancelled by the second coupler.

[37] Referring now to Figure 1, a waveguide circuit is shown which conveniently and inexpensively compensates for the polarization dependence of a tap for a silica-on-silicon waveguide device. An input port 102 is optically coupled by way of a directional coupler 100 to an output branch arm 104. The low PDL tap function is achieved through the use of a small radius bend 106 on the tapped or branch arm. [A]The same phenomenon that causes the TM polarization to more readily couple between waveguides in a directional coupler also causes a higher polarization dependent bend loss for small radius bends.

[42] Figure 5 illustrates that providing a 2mm radius bend through 90 degrees for the same waveguide as used in Figure 4, the TM mode experiences greater loss due to radiation out from the guide than the TE mode in propagating around the bend. If a tap is more efficient for TM, this bend can provide compensation for the coupling imbalance between the TE and TM modes produced by the directional coupler, so as to equalize overall the tap coupling ratios for TE and TM modes.